this volume and illustrated in satisfactory form. Fifteen British naturalists have contributed papers, and the book is perhaps the most complete treatise on the Antarctic vertebrate fauna yet published.

The birds, seals, whales and fishes, are fully illustrated with excellent plates, and much space is given to anatomy, osteology and embryology; while the economic aspects of the fauna are not neglected. Papers on the tunicates and *Cephalodiscus* are included. A few forms obtained on the voyage but which are not strictly Antarctic are incidentally noticed. Altogether the members of the staff and the contributors to the explorations and publication of the results may justly congratulate themselves on the appearance of this handsome volume at a time when general attention is unfortunately diverted from matters of science and focused on the preservation of the empire.

Wm. H. Dall

SPECIAL ARTICLES

THE CALCULATION OF TOTAL SALT CONTENT AND OF SPECIFIC GRAVITY IN MARINE WATERS[1]

To the investigator engaged in biological studies on marine problems, it is often desirable to ascertain the concentration of sea-water in terms capable of correlation with life phenomena. Such concentration records usually take the form of density determinations made with some standard type of densimeter at the prevailing temperature. These density readings, while useful as physical records, are not directly adapted to physiological use. The quantity of salts present in sea-water is a term which can be so utilized and it becomes especially valuable in view of the fact that the proportion of constituents has been shown to vary but slightly, the concentration only being subject to considerable variation. By means of the *Challenger* proportions worked out by Dittmar[2] any total salt content can be resolved into its chief constituent parts. These proportions are as follows:

	Per Cent.
$NaCl$	77.758
$MgCl_2$	10.878
$MgSO_4$	4.737
$CaSO_4$	3.600
K_2SO_4	2.465
$MgBr_2$	0.217
$CaCO_3$	0.345

It has been shown that the total salt content is directly related to the specific gravity and that one may be calculated from the other. Specific gravity determinations are made with reference to different standard temperatures. Frequently density readings are made with the temperature indicated in Fahrenheit units. These are usually referred to 60° F. as a standard temperature, and the observed density is reduced to 60° F., sp. gr. 60° F./60° F. This is easily done by means of Libbey's tables.[3] If the observed temperature is below 60° F. subtract the observed degrees of temperature from 60, multiply this difference by the correction found in the table opposite the observed temperature and *subtract* the product from the reading to be corrected. If the density is observed at a temperature above 60° F. ascertain as before the number of degrees of difference

Temp.	Correction for Reduction to 60° F.	Temp.	Correction for Reduction to 60° F.
I	II	I	II
50°	−0.000108	70°	+0.000145
51	−0.000110	71	+0.000146
52	−0.000112	72	+0.000147
53	−0.000113	73	+0.000148
54	−0.000115	74	+0.000149
55	−0.000118	75	+0.000151
56	−0.000120	76	+0.000152
57	−0.000120	77	+0.000154
58	−0.000120	78	+0.000156
59	−0.000120	79	+0.000157
60	+0.000125	80	+0.000158
61	+0.000130	81	+0.000159
62	+0.000135	82	+0.000160
63	+0.000137	83	+0.000162
64	+0.000137	84	+0.000163
65	+0.000138	85	+0.000164
66	+0.000140	86	+0.000166
67	+0.000141	87	+0.000167
68	+0.000142	88	+0.000168
69	+0.000143	89	+0.000170

[1] Published by permission of the Secretary of Agriculture.

[2] Dittmar, Challenger Reports, Physics and Chemistry, Vol. 1, Part 1, p. 138.

[3] Libbey, William, "Physical Investigations off the New England Coast," Bull. U. S. Fish Commission, 9, pp. 397–398 (for 1889).

between this temperature and 60 degrees, multiply again by the correction factor taken from the table opposite the observed temperature and *add* the resulting product to the density reading as observed on the instrument. The table of corrections is reproduced herewith.

One frequently finds density expressed as sp. gr. 15° C./15° C. This value differs so slightly from sp. gr. 60° F./60° F. that in the following discussion the treatment applied to sp. gr. 15° C./15° C. may be understood to apply to sp. gr. 60° F./60° F. without error sufficiently large to interfere with the usefulness of any biological results in which they may play a part.

More often, however, the density is expressed in terms of 15° C. referred to the temperature of maximum density, sp. gr. 15° C./4° C. Again by the help of a correction constant determined by Dr. O. H. Tittman sp. gr. 60° F./60° F. may be reduced to sp. gr. 15° C./4° C. To make this correction 0.00082 is subtracted from the value expressed as 60° F./60° F.

When the density of a sample has been reduced to 15° C./4° C. it is possible by means of Petterson's[4] determinations to ascertain the corresponding quantity of salt in the water. This tabulation gives the specific gravity readings both as sp. gr. 15° C./15° C. and as sp. gr. 15° C./4° C. of a series of sea-water samples of different density and the corresponding number of grams of total salts per liter. This latter value was determined by the silver titration method of Forchhammer.[5] Since the sea-water varies in concentration rather in the proportion of salts present, the accurate determination of any one constituent should by simple calculation give the total salts. Since Cl is present in relatively large quantity and can be determined by titration with silver nitrate to a very great degree of accuracy, it is most often used for this purpose. It has been found by Dittmar[6] that the ratio of salt to chlorine 1.8058 applies to all oceanic waters. Petterson found a slightly greater value. He carefully determined by titration the salt content of the samples just referred to and obtained a series of values which by interpolation can be used in determining either salt content from sp. gr. or sp. gr. from salt content.

Petterson's determinations are here given.

TABLE CONTAINING THE RELATIONS OF CHLORINE, SALT, AND SPECIFIC GRAVITY

Cl_2 in ‰	Salt in ‰	Sp. gr. $\frac{15°}{15°}$ Sprengel	Sp. gr. $\frac{15°}{4°}$
19.517	35.26	1.02715	1.02629
19.415	35.07	1.02701	1.02614
19.335	34.95	1.02698	1.02612
19.171	34.64	1.02668	1.02582
18.320	33.12	1.02554	1.02468
17.040	30.83	1.02377	1.02290
17.005	30.76	1.02371	1.02285
16.277	29.46	1.02261	1.02175
15.421	27.93	1.02155	1.02068
14.220	25.77	1.01983	1.01897
12.928	23.46	1.01805	1.01719
12.628	22.93	1.01761	1.01675
12.571	22.81	1.01750	1.01665
11.263	20.45	1.01570	1.01484
9.473	17.25	1.01323	1.01237
7.067	12.86	1.00987	1.00903

Since it is somewhat awkward to interpolate observed values into this series, the writer has used the data as the basis of a generalized scheme by means of which equivalents can be promptly and easily found over a range of variation of salt content somewhat greater than has been observed at Woods Hole.[7] By plotting all of Petterson's values and by prolonging the curves, the range of the table may be greatly increased though somewhat at the expense of accuracy if an extension to either great concentration or great dilution is attempted.

In the accompanying diagram (Fig. 1) the

[4] Petterson, Otto, "A Review of Swedish Hydrographic Research in the Baltic and North Seas," *Scottish Geographical Magazine*, 10, pp. 296–299, 1894.

[5] Forchhammer, G., "Om Sövandets Bestanddele og deres Fordeling i Havet," Kjöbenbavn, 1859. Engl. trans. *Philosophical Transactions*, 1865.

[6] Dittmar, Challenger Reports, Physics and Chemistry, Vol. 1, 39.

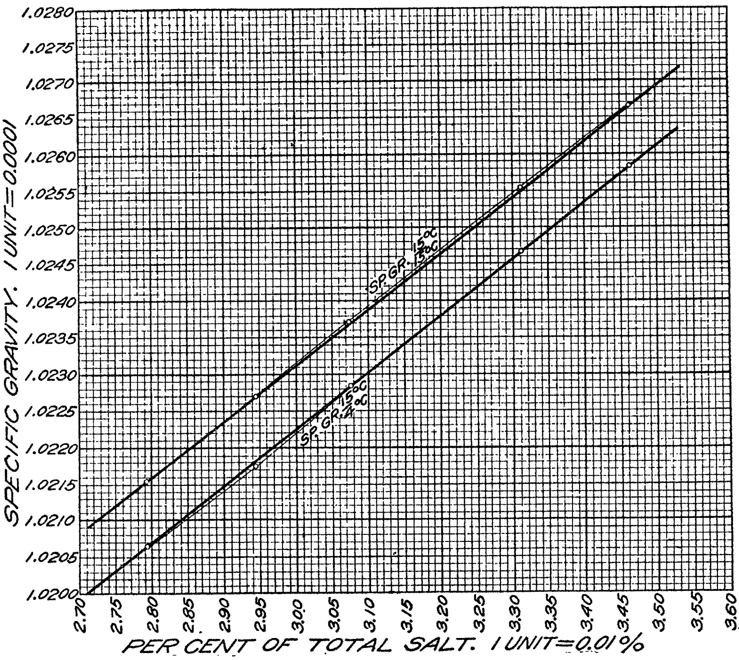
[7] Sumner, Francis B., Osburn, Raymond C. and Cole, Leon J., "A Biological Survey of the Waters of Woods Hole and Vicinity," Part I., Sec. 1, Physical and Zoological, Bull. U. S. Bureau of Fisheries, Vol. 31, Part I., 53 (for 1911), 1913.

curves expressing the ratio of sp. gr. 15° C./15° C. to total salt and of sp. gr. 15° C./4° C. to the same total salt content are drawn on a scale of absolute units. The specific gravity determination made on the basis of either of the two types of reference here mentioned, is plotted on the perpendicular axis, one unit on this axis being equal to one unit in the fourth decimal place of the sp. gr. reading. On the horizontal axis is plotted the corre-

To determine the sp. gr. by either system of reference of a sea-water solution containing a known quantity of salts, reverse the process just described.

This diagram does not give results having a degree of accuracy required for physical investigations, but is believed to be more accurate than will be required for use in biological work. The writer had only the convenience of biologists in mind in preparing these notes.

DIAGRAM FOR COMPUTING SPECIFIC GRAVITY AND TOTAL SALT CONTENT IN MARINE WATERS.



sponding scale of salt contents, one unit on the axis being equal to one unit in the second decimal place when salt content is stated in percentage. To use the table, the sp. gr. determined either as sp. gr. 15° C./15° C. or as 15° C./4° C. is sought on the perpendicular axis. The horizontal line on which this value stands is traced to the point of intersection with the line determined for the sp. gr. ratio adopted. This point of intersection stands directly above the point on the horizontal axis at which the total salt is indicated. This can be read with approximate accuracy by reference to the nearest given values.

Any one wishing to work over a wider range and with a greater degree of accuracy may use the data of Knudsen[8] in a similar way as a basis for interpolation.

For any one who is content with even rougher approximations it may suffice to apply a fairly accurate coefficient to the density readings. Karsten[9] has pointed out that when the total salt content is divided by the number represented by the first four decimal places in

[8] Knudsen, "Hydrographische Tabellen," Copenhagen, 1901.

[9] Karsten, G., *Wissenschaftliche Meeresuntersuchungen,* N. F. 1, H. I., 170, 1896.

the sp. gr. reading a coefficient is obtained which is of use in reducing sp. gr. readings to salt content. For the range of concentration likely to be seen at Wood's Hole, *i. e.*, when sp. gr. 15° C./4° C. = 1.0210 to 1.0245 corresponding to a total salt content of 2.84 per cent. to 3.29 per cent., the salt content is obtained with a probable error less than 2 in the second decimal place by multiplying the sp. gr. reading by the factor *134.5*.

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ON CELL PENETRATION BY ACIDS[1]

Preliminary Note

1. THE water-soluble blue pigment[2] in the cells of a nudibranch, *Chromodoris zebra* Heilprin, is a sufficiently delicate indicator to justify its use for the study of cell penetration by acids. Water extracts of the animal, containing this pigment and other cell materials expressed by grinding, change from a deep blue color with reddish-purple fluorescence to a delicate pink hue at a hydrogen ion concentration of $p_H = 5.6$[3]; the acidity of the body fluids of *Chromodoris* averages $p_H = 7.4$ (27°). The indicator promptly flocculates, in the form of a greenish-blue precipitate, leaving a blue solution, at $p_H = 7.6$. Within the epidermal cells the pigment is also turned green, so that it may be used to measure the penetration of alkalies; it gives results concordant with those obtained with a great variety of tissues by the neutral red method (Harvey[4]), and with neutral red-stained *Chromodoris* cells lacking the blue pigment.

The pigment occurs in two forms: as granules scattered through the superficial and deeper tissues, and dissolved in clear globular bodies located within the cells of the outer epithelium, especially along the edges of the mantle and foot. It is totally insoluble in anhydrous acetone, ether, chloroform, xylol and oils. The globules containing it do not stain with fat dyes. I conclude that the pigment is held naturally in water solution.

2. Direct measurements of the speed with which acids penetrate protoplasm were first given by Harvey,[5] who determined the time required for the testis of *Stichopus ananus* to change in color when immersed in 0.01 *N* solutions of a number of acids. I have used pieces of the lateral mantle edge of *Chromodoris* in a similar way, precautions being taken to insure comparative uniformity of the pieces in the different tests, and find that *at this concentration* (0.01 *N*) the acids employed when arranged in the order of increasing penetration-time form the series shown in Table I. Comparison of this list with

TABLE I

Penetration of Acids from 0.01 N Solutions

No.	Acid.	Time, Minutes.	
		Chromodoris. Mantle Edge. 27°.0.	*Stichopus ananus, testis* (Harvey).[6]
1	Valeric (Iso-)	1.9	2–4
2	Salicylic	3.5	0.25
3	Formic	4.5	2–4
4	Hydrochloric	7.6	9–11
5	Nitric[7]	8.4	
6	Sulphuric	8 5	
7	Lactic	8.6	
8	Oxalic	8.8	12–15
9	Tartaric	13.5	30
10	Citric	16.0	40
11	Butyric	19.0	45–60
12	Acetic	75.0	

[1] Contributions from the Bermuda Biological Station for Research, No. 39.

[2] Crozier, W. J., 1914, *Journal of Physiology*, Vol. 47, p. 491.

[3] This point changes somewhat with the age of the extract, in the case of alcohol (95 per cent.) and other permanent solutions of the pigment. The p_H values given were obtained by titration with phosphate and acetate mixtures, checked by gas chain measurements on alcohol and formalin solutions of the pigment.

[4] Harvey, E. N., 1914, Papers from the Tortugas Lab., Vol. VI., p. 133.

[5] Harvey, E. N., 1914, SCIENCE, N. S., Vol. XXXIX., p. 947.

[6] Only those acids which I have studied have been taken from Harvey's table, which includes a number of others.

[7] The differences in penetration-time for Nos. 5–8 are slight at this concentration, but their separation is justified on the basis of the dilution curves.